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ORIGINAL PAPER

Assessment of existing and future rail freight services and Technologies for low Density High Value Goods in Europe

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Abstract

Introduction In recent years there have been major changes in the composition of cargo to the point where, in Europe, semi-finished products (e.g. car parts) and finished goods represent the greatest transport demand. This type of cargo is typically of lower density and higher value (LDHV) than previous goods and requires faster and more reliable transportation. Currently, LDHV goods are predominantly transported by road.
Methodology This research applies qualitative approach with an online survey consisting of 24 industry experts in assessing the 'existing' solutions for competitive rail freight service operation for LDHV cargoes, plus the proposed 'future' (i.e. in 7 years' time). The results are presented in the form of a 'GAP' analysis that examined three core themes: 'wagon', 'train and hubs' and 'business quality and planning'.
Results The study finds that, under the theme of wagon, the provision of an electrical power supply to each individual rail freight wagon is deemed important. In the train and hubs theme, the research suggests that greater importance is assigned to terminal access and functionality, rather than their overall cargo handling capabilities. In the business quality and planning theme, one issue in particular stood out: the ability to freely integrate freight and passenger services; this is considered a key requirement of the railways of the future.
Conclusion This research contributes significantly to the field by demonstrating that the desire to transport LDHV goods by rail freight has potential. There are difficulties in integrating freight and passenger services, but technical innovation can allow freight services to operate at similar performance levels to passenger services. This research has identified a number of such technical innovations. It is envisaged that the adoption of these innovations, by the rail industry, will lead to a modal shift from road to rail for the transport of LDHV goods. The analysis suggests that the emerging technologies presented in the survey (e.g. horizontal transhipment) have the capability to promote modal shift by directly strengthening the rail freight service offering, as an alternative to less sustainable modes such as road. Finally the research is revelatory in that this topic has not been addressed by academia nor the industry previously, and has identified future research gaps and questions with potential impact that researchers can look to answer in the future.

Keywords Gap analysis · Rail freight · Low density high value cargo · Operations · Technology · Future rail freight services · Europe

1 Introduction

Generally, rail freight transport is utilised by customers to move low value high volume cargo such as coal (e.g. for power plants), steel (e.g. for ship manufacturing), and other raw materials for industrial input. In recent decades, there have been major changes in the composition of the cargo, so that now semi-finished products (e.g. car parts for assembly) and finished products (value added through final process)

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present the greatest demand for transport in Europe [1, 2]. This type of cargo is typically lower density and higher value (LDHV) and requires faster and more reliable transportation. Currently, LDHV goods are predominantly transported by road transport. Aside from faster and more reliable services, road hauliers also offer a flexible, customer tailored, door to-door service. In contrast, rail freight transport is typically slower door to door and in many cases unreliable [3]. This may in part be attributed to lower priority in timetable path allocation, compared to national and international passenger rail services [4]. The average transport haul is also shorter in Europe, which favours road transport – the EC currently considers 300 km to be the distance at which rail becomes economically competitive with road transport.

Based on the work by Woroniuk et al. [4] the current research adopt the position that in order to achieve similar priority in path allocation, rail freight vehicles must have service characteristics (e.g. speed, acceleration and braking) comparable with passenger services. The research follows the findings of Woroniuk et al. that the proposed freight services should not impact negatively on the current passenger service, but rather match them by enhancing operational, technological and logistics capabilities. The proposed rail freight services will serve the needs of customers for LDHV cargoes. With this proposed service in mind, this research paper presents the opinion of industry experts, using an online survey method to assess 'existing' and proposed 'future' solutions, in the form of a 'GAP' analysis.

The gap analysis will align potential solutions with a series of market requirements for the transport of LDHV goods. Transport solutions incorporate some operational change but are largely technology driven interventions but is broadly defined as a market focused, high performance, mixed running rail service, that provides reliable, flexible and secure seamless transportation of LDHV goods from door to door.

The research begins with the vehicle, train and logistics operation developed in the SPECTRUM rail freight project [5]. The vehicle will have speed characteristics similar to passenger vehicles such that acceleration is 0.5 m/s2, maximum speed is 140-160 km/h with an average speed of 120 km/h and can decelerate at 0.7 m/s2 with an estimated axle load of 17 t.The train will operate in shorter loco hauled fixed formation (unbreakable) freight trains consisting of a maximum of 10–15 vehicles.

The wagons will be hauled by an electric loco with provision for last mile terminal operations and off line (no electrical power supply) operations using diesel or battery power. For the purposes of interoperability the locomotive will have the capability to operate on a number of European voltages.

In many cases, technological interventions in the rail sector come with considerable investment costs. The canvassing of expert opinion presented in this analysis will identify those technological solutions with the greatest potential and estimate the likely impact on the LDHV transport solutions. This will assist in focusing the direction of future research and investment in rail freight based technologies.

2 Background

The 2011 EU Transport Whitepaper presents ambitions for modal shift: '30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050'. This should be facilitated by 'efficient and green freight corridors' and by 'optimising the performance of multimodal logistic chains, including by making greater use of more 'energy-efficient modes' [6]. This ambitious objective is set against the backdrop of a declining rail freight market share for inland (intra-EU) transport, having decreased from 20.2%, in 1995, to 17.4%, in 2011. In contrast the share of road freight has increased from 67.4%, in 1995, to 71.8%, in 2011 [7].

Although the U.S freight transport system has very different (operational, technical and geographical) conditions, road and rail freight increased from 29.8% (1239 btkm) and 37.3% (1554 btkm) respectively, in 1990, to 35.2% (1929 btkm) and 42.2% (2309 btkm) by 2009. This has been at the expense of rail passenger and waterways transport [7]. Experts point out that liberalised (in particular downsized and/or limited federal economic regulation) [8] freight oriented railways [9], including privately owned and operated railways, have helped the United States freight railway industry succeed in gaining higher market share [10, 11]. It should be noted that the European railways are passenger oriented, originating from government owned and operated national railways with a focus on national priorities (not simply for economic advantage) [11, 12]. Although some incumbents such as DB Schenker or SNCF Fret have become standalone freight operators, and some previously public rail freight operators became wholly private (e.g. English, Welsh and Scottish Railways (EWS) the share of independent private operators is insignificant, not least since many early private companies were subsequently bought out by incumbents looking to compete in new markets, e.g. Rail4Chem eventually becoming part of SNCF. The European Commission has adopted and implemented, at various levels, many directives - including three Railway Packages, with ambitions for a fourth - in an attempt to make the European railways more competitive and achieve modal shift targets. The Commission has also funded research initiatives to upgrade and integrate the infrastructure and rolling stock, to achieve pan-European services and improve operational practices [5, 12–14].

Previous research on modal choice [15] has suggested that the modal shift to rail can be achieved by, among others, meeting customer's logistics requirement in terms of reliability. It has been proposed that one route for LDHV goods would be by implementing a rail freight service with operational (speed, acceleration, braking) characteristics similar to a passenger train [16]. The potential LDHV market is estimated to be 1.9 billion tonnes, or 12% of the total tonnage currently transported by road in the EU-27 and Switzerland (CH), over distances of 200 km [1]. This paper further explores this finding, cross checking it with an expert based analysis.

3 Research approach

The attainment of a quality service became a pivotal concern during the 1980s [17]. A major concern of managers, in dynamic and changing environments, has been the introduction and modification of their organisations to improve performance. For this reason, performance measurement has become a major subject of surveys. Manufacturing organisations were among the first to realise that concentrating on financial indicators is not adequate to truly capture service performance. Service organisations followed suit and focused on non-financial aspects of performance, in addition to financial indicators [18]. Service quality, elusive and indistinct in construct, is considered a critical dimension of competitiveness, in the increasingly global competitive market [17, 19]. Also, the quality of services has a significant influence on customer satisfaction and customer loyalty [20]. A study by [21] successfully used a gap analysis method advocated by [22] and suggested that closing the 'gap' between customers' expectations and perceptions is critical to delivering a quality service.

Perceived service quality is the result of a comparison of performance with what the consumer feels a company should provide [23]. In some respects a gap analysis is comparable with benchmarking [24] interpreted benchmarking as a comparison of performance level, process and practices, to introduce improvement in a company or sector.

By extending the methodologies presented above to the field of rail freight transport, the current research applies a GAP (difference between 'existing' and desired 'future' scenarios) analysis, using an online survey, that ultimately aims to identify the gap between the market requirements for the transportation of LDHV goods and existing rail freight solutions. The survey participants are experts working directly in the rail freight sector as operators, infrastructure managers, vehicle system builders (including wagon, brakes and power supply manufacturers) and in some cases expert researchers themselves. They were invited formally to the survey, as it was felt that a non-random approach would raise the quality of the work due to the fact that the opinions are expected to be based on their expert knowledge and experience in the specialised field. The selection of such survey participants was based on the authors' assessment of the relevance of their skills to this specific field. A questionnaire was developed and piloted internally and focussed on three distinct areas, each on a separate worksheet: 'The Wagon'; 'Trains & Hubs'; and 'Service Quality & Planning'.

3.1 Structure profile of survey participants

A total of 27 expert peers were approached with 24 respondents (89%, see Annex 1) completing the survey. A broad demographic of respondents, from a variety of organisations, of varying business types, were consulted. This included research organisations; logistics service providers; system builders and manufacturers; academic institutes; international unions; infrastructure managers; and consultants. The geographic spread was: Italy (1); Switzerland (1); Netherlands (2); France (3); Belgium (4); Germany (4); Sweden (4); and UK (5), while the industry breakdown was: infrastructure managers (2); transport operators (3); representative bodies (3); Logistics service providers (5); rail systems/technology manufacturers (5); and research and consultancy organisations (6). Participants approached were from a variety of management levels, though responses were received predominantly from senior management level (85%), with the remaining 15% from junior management.

The proposed measures were assessed in terms of gap (between existing and proposed transport solutions), potential (modal shift, manufacturing and logistics competitiveness) and difficulty (technical, operational and commercial). By combining measures deemed to be compatible with one another, such as GAP and Potential for example, an additional 8 unique ranking criteria were derived.

3.2 Questionnaire

The survey consisted of a total of 21 questions, of which the first six focused specifically on the profile of the respondent. The Questions 7–21 (see appendix 1) were research questions which were arranged into three distinct areas, each on a separate worksheet (page).

- Q7-Q10 on Wagon
- Q11-Q17 on Trains and Hubs
- Q18-Q21 on Commercial, Service Quality and Planning

Within each of the worksheets the 'existing' and desired 'future' scenarios were described and the respondents were requested to assess (on a scale of 1 to 5, see Annex 2 for details) the questions in terms of:

1) GAP – defined as the difference between 'existing' and desired 'future' scenarios
2) Difficulty – that means how difficult is the objective perceived to be in terms of:

- Technical difficulty
- Operational difficulty
- Commercial difficulty

3) Potential – defined as, if the goal were achieved, what is the outcome anticipated to be, in terms of:

- Modal Shift - the potential for rail freight to attract additional logistics business from other modes of transport on the basis that increased modal shift from road to rail will lead to greater sustainability.
- Logistics Competitiveness - Logistics competitiveness and the potential to improve the EU logistics industry, thereby improving the competitive advantage of Europe in the global market
- Manufacturing Competitiveness - The potential to improve the competitive position of EU rail equipment and system builders and therefore the ability to increase the market share of industrial rail products in the world

3.3 Grade ranking (GR)

These individual assessments could then be aggregated, and create a system of grade ranking to address magnitudes of gap, both the 'difficulty' and 'potential' of measures., We have described these as grade rankings. The development of a series of 'combined assessment indices' reveals further information about the potential innovations, technologies and changes in policy described in each of the survey questions. In total, an eight 'combined assessment indices' have been developed, labelled GR1 to GR8 below:

- GR1 = Grade x Modal Shift (Potential)
- GR2 = Grade x Logistics Competitiveness (Potential)
- GR3 = Grade x Manufacturing Competiveness (Potential)
- GR4 = Grade x Σ Potential
- GR5 = (Grade x Σ Potential) / Σ Difficulty
- GR6 = (Grade x Manufacturing Competitiveness) / Technical Difficulty
- GR7 = (Grade x Modal Shift) / Average Difficulty
- GR8 = (Grade x Logistics Potential) / Average of Operational & Commercial Difficulties

It is important that Grade remain a common denominator. In combination with the measures above, the Grade property adds an additional, decisive dimension. For example, if two scenarios from the same question scored equally for a particular measure, it would seem appropriate to further investigate the measure. In summary, not only do these measures provide a new set of criteria by which scenarios may be assessed, they also allow differentiation between results.

4 Analysis and discussion of the results

It can be argued that some of the measures used to assess the two ('existing' and 'future') scenarios are compatible whilst others are not. Compatible measures are those that may be combined to form new measures. The results of these measures are summarised for each scenario (Q7 – Q21) in Table 1. From this table it is possible to examine each survey question (or scenario) by the 8 GAP Rankings (GRs) discussed in section 3.3. The GRs based on the three core themes: Wagon; Train and Hubs; and Commercial, Service Quality and Planning are analysed in the following subsections.

4.1 Wagon

Questions 7 to 10 were principally concerned with assessing the potential of the proposed wagon based solutions. Typically the operational life of a wagon can be 40 years. The advantage of this longer life may mean its inflexibility or incapability to respond to market demand or technological advances e.g. lack of accommodating capability of different types of cargo units; wagon powered with electricity and with cargo condition monitoring system for reefer goods; easier and less costly transhipment etc. The future of rail freight service is largely depends on how the new wagons accommodate such improvements. The results of these questions are presented in Table 1 (at its beginning part).

Analysing Table 1, one response stands out. This is Q9 and was about the provision of electrical power supply to the individual wagon. Q9 has the greatest value for every GR value apart from GR3. There is reference made in the question to the ability to control the temperature of the refrigerated containers that are being transported. It should be noted that this provision opens many more opportunities than just temperature control. The proposed rail freight services focus on LDHV goods brings additional requirements beyond those of a traditional freight wagon. Security, for instance, has increasing importance, since the cargo type is of higher value than traditional bulk cargo. The provision of electrical power supply to individual wagons facilitates the use of IT monitoring systems as a deterrent to potential thieves. The study finds found that a largest group of respondents (32%) answered (for details see Fig. 1) with option 5 i.e. "achieved nowhere" suggesting a very large GAP at present. From Fig. 1 it can also be seen that 50% of respondents thought that wagons may be equipped with an electrical power supply by integrating existing technological, operational or business models and that deployment is possible within 1–2 years with minimal capital investment (see Annex 2). A quarter of respondents thought that technical implementation would be slightly more difficult responding with option 4 – significant scientific research and significant capital investment required with deployment possible within 5–7 years (see Annex 2).

GR3 assesses the manufacturing potential of a scenario. In this instance Q7 has the greatest value for manufacturing

Table 1 Results of GAP Ranking (GR) (Q7-Q21)

Gap Ranking (GR)	Q	1	2	3	4	5	6	7	8	SUM
Wagons	7	8	16	16	40	4.4	5.3	2.7	5.3	97.8
	8	12	14	12	38	5.4	6.0	5.1	5.6	98.2
	9	17.5	20	15	52.5	8.8	7.5	8.8	10.0	140.0
	10	12	16	14	42	4.9	4.7	4.2	5.8	103.7
Trains and Hubs	11	15	15	15	45	5.0	3.8	5.0	6.0	109.8
	12	14	10.5	10.5	35	5.8	5.3	7.0	5.3	93.3
	13	16	16	12	44	6.3	6.0	6.9	6.4	113.5
	14	8	12	12	32	5.3	6.0	4.0	6.0	85.3
	15	15	25	15	55	6.9	7.5	5.6	8.3	138.3
	16	9	9	12	30	4.6	6.0	4.2	4.0	78.8
	17	3	9	9	21	3.2	4.5	1.4	4.0	55.1
Commercial, Service Quality and Planning	18	12	14	12	38	5.4	6.0	5.1	5.6	98.2
	19	20	20	15	55	6.9	5.0	7.5	8.0	137.4
	20	18	18	13.5	49.5	7.6	6.8	8.3	8.0	129.7
	21	20	20	15	55	11.0	7.5	12.0	13.3	153.8

potential. Q7 relates to the ability of a wagon to transfer all container types. It is not unrealistic that a 'one size fits all' freight wagon has greater manufacturing potential than just the provision of electrical power supply, since an electrical power supply is unlikely to be required for the transportation of bulk cargo, which still forms the majority of rail freight cargo. Interestingly, the SUM GR value is the lowest of the wagon related scenarios. It scores particularly low in GR7. Gr7 is a function of modal shift

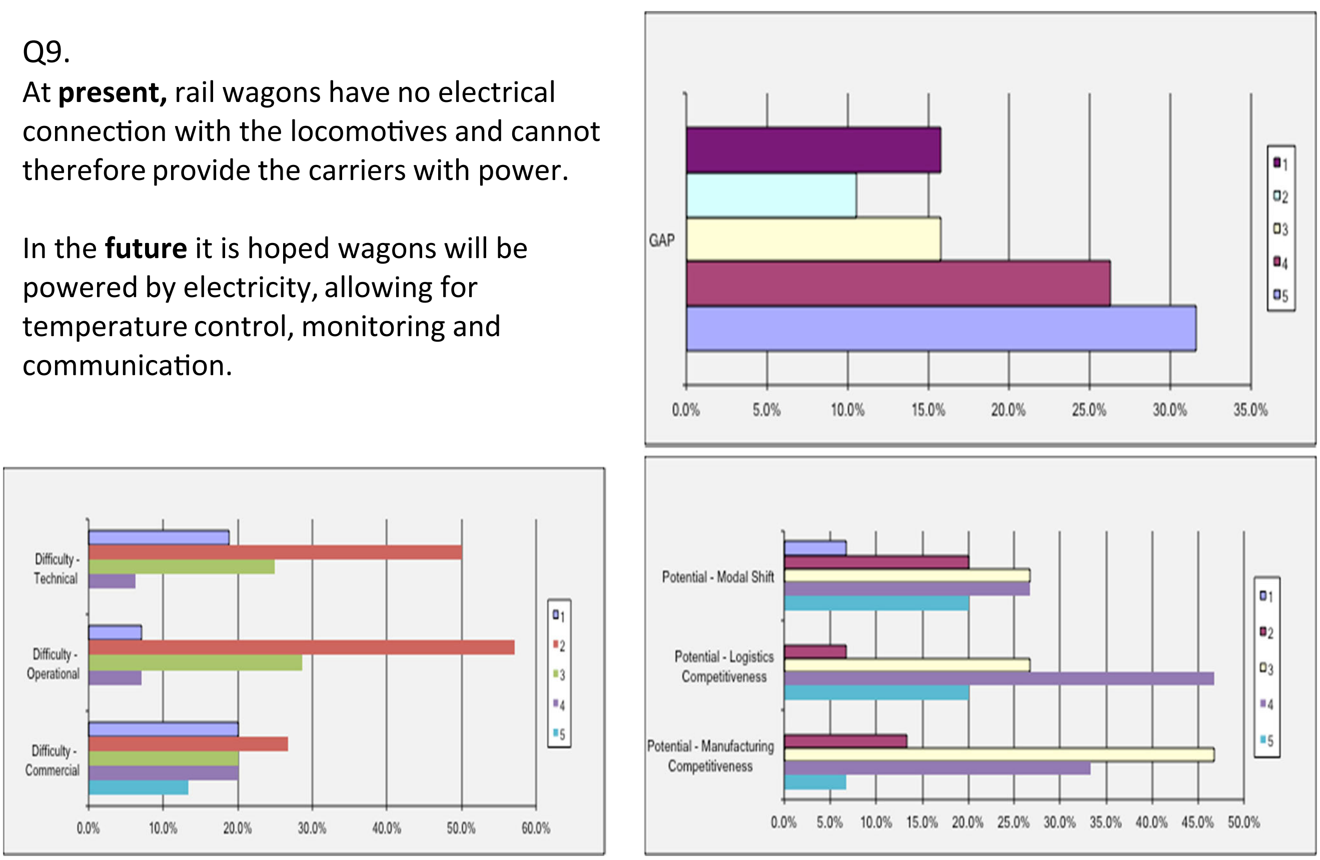

Fig. 1 Provision of electrical power supply to individual wagon

potential (see section 3.3) but also technical difficulty and respondents have suggested this measure to have average modal shift potential and an above average difficulty rating. The question Q10 has several elements but, crucially, it states that transhipment costs are no longer an issue. As might be expected, this therefore scores highly in those measures that incorporate intermodal logistics competitiveness, where transhipment time and associated costs are often regarded as significant barriers to successful intermodal transport. In terms of technical difficulty, half of the respondents thought that with the integration of existing technological, operational and business models, deployment of horizontal transhipment, would be possible within 3–4 years with significant investment and in terms of operational difficulty, largest group of respondents say that the integration of existing technological, operational and business models deployment would be possible within 3–4 years with significant investment required.

4.1.1 Policy implications for novel freight wagons

There is little policy with regard to freight wagons save the high level of regulations, but even these can be delineated as a relatively standard post 1945 freight wagon, and the addition in the 1960s of new brake systems. The uniformity of freight wagons in Western and Eastern Europe means that the potential shortage of wagons pre 1991 was assuaged by the release of excess capacity from the former COMECON countries. The very low level of asset value and the surplus volumes in the wagon fleet has meant that there has been little appetite for novel electrically powered wagons with such features as condition monitoring, power supplies for temperature controlled containers etc. However the need for such modern wagons has been seen by the industry and the European Union and directly influenced by this research and others in the SPECTRUM project, the Shift2Rail Joint Undertaking, a joint venture between the sector and the EU, has made the development of such wagons a research and innovation priority, with funding, in its 2015 Multi-Annual Action Plan [25]. What is not addressed in the plan are business models that can generate returns on investment to attract operators or leasing companies to invest in such new innovative wagons, although this has since been explored by Siciliano et al. in this very journal [26].

4.2 Trains and hubs

Questions 11 to 17 were principally concerned with assessing the potential of solutions based on Trains and Hubs. Currently the service offering capability of freight trains and hubs are far behind its intra-modal and inter-modal competitors, for example, in terms of acceleration and deceleration capability compared to passenger trains running on the same rail network; price for a origin-destination multimodal service; whereabouts of cargo etc. The future of rail freight service is largely depends on how the rail sector make significant improvements in such areas. The results of these questions are presented in the middle of Table 1.

Looking at the SUM column of Table 1 there is immediately a stark contrast between several Trains and Hubs scenarios. Q16, for example, relates specifically to increased terminal cargo handling capacity. This scenario has the lowest overall GR whereas Q15 has the highest overall GR which relates to terminals, but with focus on time allocation at terminals, stating a minimum amount of time (to facilitate faster transhipment) should be allocated to each train, as and when required. The study found that the desired future scenario of a minimum allocated time at the terminal for all vehicles has been identified as a large gap by the survey respondents, − nearly 30% choosing option 5 (see Fig. 2). In terms of technical difficulty, 35% of respondents have selected option 2, which states integration of existing technological, operational or business models with deployment possible within 1–2 years with minimal capital investment (see Annex 2). Just under 30% of respondents felt technical difficulty to be greater than this, stating that with the integration of existing technological, operational and business models, deployment would be possible within 3–4 years and requiring significant investment (see Fig. 2 and Annex 2). About 38% of respondents stated the ability to assign a minimum amount of allocated time at terminal would go some way to achieving the EC targets for modal shift anticipating contribution towards a 15% shift by 2020 and 25% by 2050. About 25% of respondents were more optimistic in their views of the potential modal shift, stating partial achievement of White Paper targets of 22% by 2030 and 38% by 2050. Almost 38% responded with option 5, which suggests that assigning a minimum amount of time for loading and unloading in terminals would significantly increase the relative competitiveness of intermodal transport. The remainder of respondents were also positive, but opinion was divided equally between options 3 (slightly increase) and 4 (increase) (see Fig. 2 and Annex 2).

Like Q15, Q13 has a high GR SUM value when compared to Q16. Q13 states that, in the 'future', it is hoped terminals are accessible easily and situated throughout Europe. Nearly 44% of respondents rated the technical difficulty of widespread open access terminals to be overcome through the integration of existing technological, operational or business models, with deployment possible within 1–2 years and with minimal capital investment (see Annex 2). This piece of analysis therefore suggests that greater importance is assigned to terminal access and functionality than to their overall cargo handling capabilities. Attention should also be drawn to GR2, which aims to assess logistics competitiveness potential which achieved higher value (16) compared to average value for GR2 (approximately 13.8). But Q15 has even higher (than Q13) value for GR2, almost double the average, suggesting very strong logistics competitiveness potential for intermodal rail freight service providers.

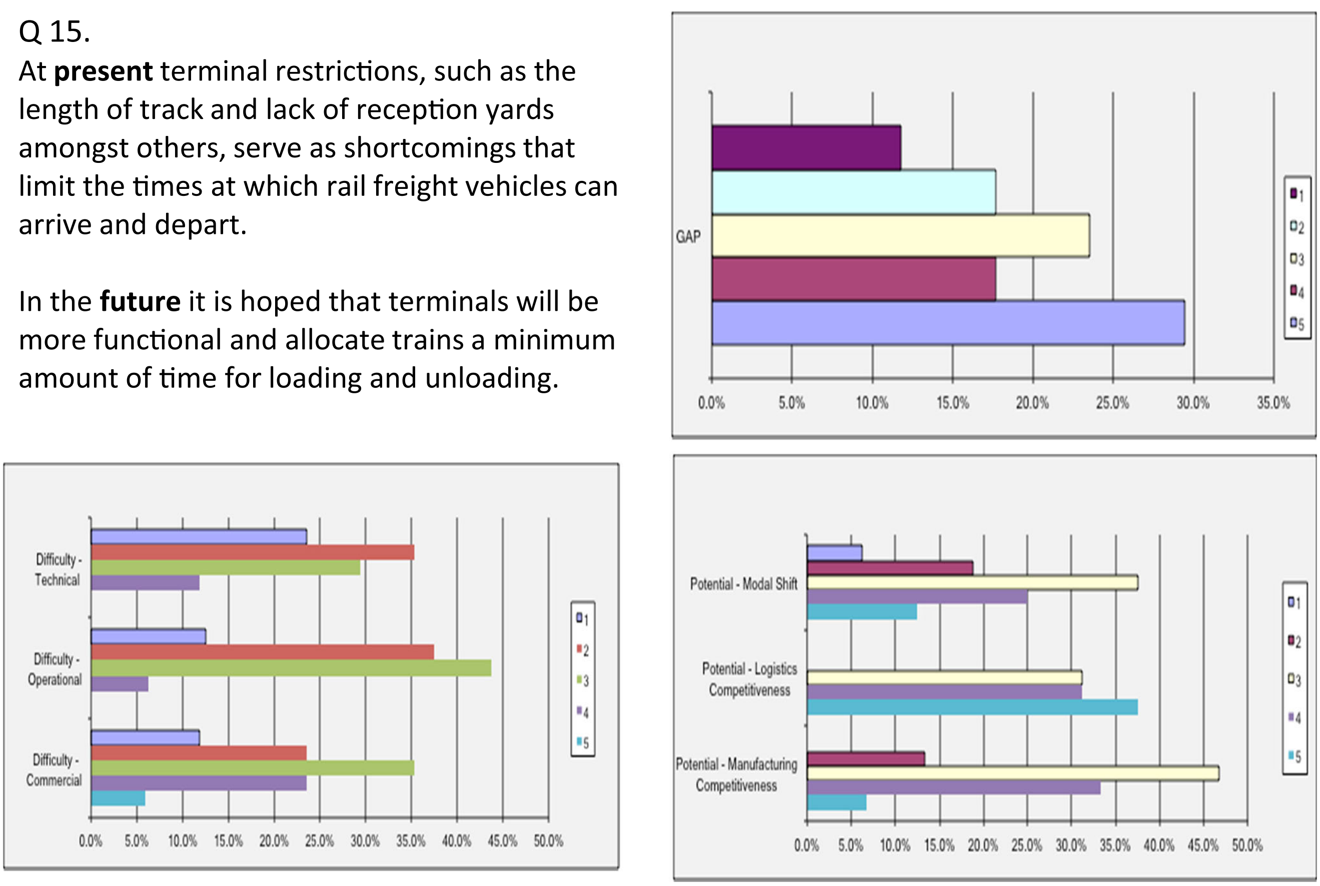

Fig. 2 Rail terminal ability to handle/tranship vehicles and cargoes

4.2.1 Policy implications for rail terminal access

The European Union Railway Packages, a strategy for the revitalization of the railways in Europe, against a backdrop of decline, separated of infrastructure and operations and opened rail markets to competition. The EU used a mixture of statutory instruments, and these were delivered in railway packages, 2001, 2004 and 2007, with varying success. The first package permitted open access for national rail services across EU. The second package aimed to build an integrated European railway area, in particular by opening up more quickly the international rail-freight market, with a new directive on railway safety and the establishment of a European Railway Agency. The third opened up international passenger rail services from 2010 and the introduction of a certification system for locomotive drivers. However, in 2010 the Commission reported that "it has not been possible to improve the overall modal share of rail freight and passenger transport in line with the objectives set in the 2001 Transport White Paper… monopolistic positions still exist in many Member States both for freight and for passenger transport services." [27].

In the area of terminal access, the early packages had failed to require statutory and equal access to rail hubs on an open and transparent basis. Thus in many EU states rail terminals are monopolies, either state monopolies biased towards previously state owned rail incumbents, or privatised monopolies with no obligation to maintain fair and reasonable access to all. This has been recognised by the EU and the Fourth Railway Package was intended to meet this shortfall, amongst others, but has been resisted, amended and curtailed by member states, largely Germany [28, 29].

4.3 Commercial, service quality and planning

Questions 18 to 21 were concerned with assessing the potential of solutions concerned principally with Commercial, Service Quality and Planning. The results of these questions are presented in Table 1 (see at end part). The Q21 has the highest GR SUM value. The scenario described takes quite a radical approach to capacity management stating that, in the 'future', it is hoped that freight and passenger trains will be given equal priority. Respondents describe the GAP to freight trains being given equal priority as passenger services as wide. Nearly 40% of respondents selected option 5, which means that this (equal priority) is currently achieved nowhere. This measure scores particularly well in GR7 and GR8, where it is approximately double the average. GR7 is a particularly interesting measure since it incorporates modal shift – a key objective of European Transport White Paper Policy - but also incorporates all difficulty factors, suggesting the measure is both promising and achievable. Many respondents were very positive about the modal shift potential of giving equal priority to freight train services such as the SPECTRUM concept [5]. Nearly 38% stated they expected partial achievement of the White Paper objectives for modal shift - specifically 22% by 2030 and 25% by 2050. 40% of respondents rated the operational difficulty of equal priority and quality train paths as achievable through the integration of existing technological, operational and business models, with deployment possible within 1–2 years with minimal capital investment (see Fig. 3 and Annex 2). The study finds that 50% of respondents stated that equal priority and quality train paths would produce an increase in the relative competitiveness of rail intermodal transport and that the majority of respondents (over 60%) suggested that the equal priority and quality train paths would allow rail system equipment suppliers to stay ahead and strong in worldwide service networks and co-operations (see Fig. 3 and Annex 2).

Comparisons may be drawn between Q20 and Q21, both of which are very customer focused in addressing modern supply chains needs through increased frequency and reduced lead-time. It is interesting therefore that they score the same for GR8, which is an intermodal logistics potential focused measure that includes commercial difficulty. The majority of respondents (over 50%) viewed the technical difficulty of reducing lead - time through the integration of passenger and freight services as possible to … overcome through the integration of existing technological, operational or business models with deployment.. and possible within 3–4 years requiring significant capital investment. The GR measures Gr1 – Gr8 are weighted somewhat in favour of those questions where respondents identify a large gap i.e. 'achieved nowhere'. Quite rightly, those scenarios which are currently achieved 'nowhere in Europe' should be the focus of some attention. It is interesting therefore to take a look at Q18, which scores the lowest GR SUM value, despite having a relatively large gap (see GR4 in Table 1). On this question, the majority of respondents viewed the technical difficulty, track and trace system, as achievable, with the integration of current technological, operational or business models with deployment possible within 1–2 years with only minimal capital investment.

Fig. 3 Freight trains' path allocation priority similar to passenger trains

4.3.1 Policy implications for equal 'freight and passenger scheduling'

In order to support quality reliable international rail freight services, the EU Commission has repeatedly proposed giving priority to international freight in operation and train path allocation along defined transnational corridors. These would have regulated service quality levels and would operate rather like the dedicated high speed networks built in Europe for passengers. The problem was, they weren't dedicated, nearly all of the routes were existing mixed use paths where passenger trains had priority. This problem, which is one the USA is currently facing in reverse [30], was too much for the industry and Deutsche Bahn, in it's role as infrastructure manager in Germany and growing international and freight operator, came down in marked opposition, so much so that every Annual Report from 2007 to 2010 states blunt opposition to any such proposal [31].

5 Summary and conclusion

The research explored 'existing' and 'future' rail freight solutions for LDHV cargo transport by rail, using a GAP analysis methodology, implemented using an online survey questionnaire, completed by 24 participants. The analysis examined three core themes; 'Wagon', 'Train and Hubs' and 'Commercial, Service Quality and Planning'. The study found that the provision of an electrical power supply to each individual rail freight wagon was deemed important, with the ability to provide power to refrigerated containers for the transportation of refrigerated goods. The 'Train and Hubs' theme concentrated in part on terminal operations and facilities and the research findings suggested that greater importance be assigned to terminal access and functionality, rather than to their overall cargo handling capabilities. Regarding 'Commercial, Service Quality and Planning', the issue that stood out was the ability to freely integrate, through equal priority, freight and passenger services, which should be considered a key requirement of the railways of the future.

This research has demonstrated that the desire to transport LDHV goods by rail freight, and the associated objectives and ambitions, have significant gaps and also significant potential impact in the eyes of our surveyed rail professionals. An effective integration of freight and passenger services faces difficulties (e.g. due to differing operational characteristics, such as speeds, acceleration) that can be overcome by technical and operational innovations that allow freight services to operate at similar performance levels to passenger services. This research identifies a number of such potential technical innovations and provides an expert based ranking to guide a researcher, practitioner or policy maker to focus on a chosen combination of ease or potential. This focus might be further research into feasibility, business planning or changes to regulation or policy.

This research has identified a number of such technical innovations. It is envisaged that the adoption of these innovations, by the rail industry, will lead to a modal shift from road to rail for the transport of LDHV goods.

The analysis suggests that the emerging technologies presented in the survey (e.g. horizontal transhipment) have the capability to promote modal shift by directly strengthening the rail freight service offering, as an alternative to less sustainable modes such as road. Finally the research is revelatory in that this topic has not been addressed by academia nor the industry previously, and has identified future research gaps and questions with potential impact that researchers can look to answer in the future. We commend the reader to review the references where many of the technical, operational and financial possibilities are detailed and assessed in more detail.

The study finds that, under the theme of wagon, the provision of an electrical power supply to each individual rail freight wagon is deemed important. In the train and hubs theme, the research suggests that greater importance is assigned to terminal access and functionality, rather than their overall cargo handling capabilities. In the commercial, service business quality and planning theme, one issue in particular stood out: the ability to freely integrate freight and passenger services; this is considered a key requirement of the railways of the future.

In terms of policy, the technical development of novel powered freight wagons has been given prority and funding under the Shift2Rail Joint Undertaking. With respect to open and equal access to terminals and an equal planning priority for freight and passenger rail, the policy has been stymied by member state opposition.

The experts in this research collectively envisage that the adoption and implementation of these innovations, by the rail industry, will help achieve modal shift from road to rail, for the transport of LDHV goods. The potential LDHV market for rail is estimated to be 2% of the total tonnage currently transported by road in the EU-27 and Switzerland (CH), over distances of 200 km.

This research contributes to the field by demonstrating that the desire to transport LDHV goods by rail freight has potential. There are difficulties in integrating freight and passenger services, but technical innovation can allow freight services to operate at similar performance levels to passenger services.

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In order that our paper is of reasonable size, an in-depth analysis and discussion are conducted only on the results of a few; but most interesting among the three core themes: Wagons, Trains and Hubs, and Commercial, Service Quality and Planning; questions.

The discussion and analysis on the results of remaining questions are not included in the paper. The readers can contact the corresponding author for the question specific results and analysis in the spirit of shared open data.

Annex 1

Table 2 The survey questionnaire (without profile related questions)

Q7	'At present, most wagons are designed in such a way that they cannot accommodate all cargo unit types (ISO containers, swap bodies and semi-trailers). In the future it is hoped that rail wagons will be able to accommodate all different types of cargo units and that cargo units are suitable for all surface transport modes'.
Q8	'At present, cargo condition-monitoring systems are well established in trucking and maritime shipping sectors, where measures are taken in the case of power failure. However there is currently no such system for rail. In the future cargo units including reefers may easily shift transport modes and be monitored during transit with appropriate measures in place to mitigate such events as power failure.'
Q9	'At present, rail wagons have no electrical connection with the locomotives and cannot therefore provide the carriers with power. In the future it is hoped wagons will be powered by electricity, allowing for temperature control, monitoring and communication.'
Q10	'At present the transhipment of wagons and cargo units between rail and other modes is performed using different methods and equipment. Typically cranes are used for high volume cargo units and reach-stackers for lesser volumes. There are methods for wagon transhipment, such as lateral transhipment technology, but these are costly and require a side platform. In the future it is hoped that wagons will be inherently flexible, capable of accommodating different types of cargo units that may be loaded and unloaded at a variety of locations as per the needs of the customer. Importantly, the cost of transhipment will no longer be the issue presented today.'
Q11	'At present a freight train today, performs significantly worse than a passenger train in terms of acceleration, deceleration and top speed and freight trains often have to wait in sidings for passenger services to pass. The greater number of stops exhibited by the passenger service also impacts on the reliability and transit time of the freight service. In the future a freight train with performance characteristics that allow it to successfully integrate with passenger services is envisaged.'
Q12	'At present many customers complain about difficulties in knowing where their cargo is located, when it is due to arrive and when it is late. In the future it is hoped that the implementation of technologies similar to Radio-Frequency Identification (RFID) will allow the customer to track the location of their cargo.'
Q13	'At present some operators have dedicated terminal facilities. However, many require publicly accessible terminals, which are not very common and a limiting factor in rail freight transport. It is hoped that in the future terminals will be far more accessible and spread throughout Europe and allow all operators access to load and unload.'
Q14	'At present many terminals require the use of a diesel locomotive in order to access the terminal due to a lack of electrification. In the future it is hoped the majority of terminals will be accessed directly using an electric vehicle and, where not possible, a diesel vehicle will be provided at low cost.'
Q15	'At present terminal restrictions, such as the length of track and lack of reception yards amongst others, serve as shortcomings that limit the times at which rail freight vehicles can arrive and depart. In the future it is hoped that terminals will be more functional and allocate trains a minimum amount of time for loading and unloading.'
Q16	'At present there is limited cargo handling capacity at terminals impacts negatively on rail freight transit time. In the future it is hoped terminals will have the facility to handle large amounts of cargo so as not to impact on the rail freight transit time.'
Q17	'At present terminals offer little in the way of value added services. In the future it is hoped the majority of terminals provide many value added services, such as the repair of damaged or broken wagons, electrical power supply and staff amenities.'
Q18	'At present many cargo shippers use trucking to serve their logistics needs. To use intermodal transport they must ship significantly greater volumes to be cost effective. Cooperation between carriers transporting smaller volumes of cargo is not common. In the future it is hoped transport companies selling capacity on a variety of transport modes will be more common. Control will be provided by track and trace systems and the cargo owners will have the ability to redirect the transport and even change the transport mode in times of crisis.'
Q19	'At present freight trains in Europe generally have long lead-time, many lines having a maximum speed of between 30 and 50 km/h. Road transport is much faster, even considering the adverse effects of congestion. In the future it is hoped a Spectrum type train, with a faster lead-time due to better adjustment to passenger traffic, will be available to customers.'
Q20	'At present congestion on some parts of a freight train corridor can be stationary for large periods of time. In the future it is hoped a high service frequency and a train that is adapted to integrate with passenger traffic, will allow shippers to be sure that the cargo is delivered on time to the customer.'
Q21	'At present when planning a train path the freight vehicle is not given the same priority as passenger trains. In the future it is hoped a Spectrum type train and passenger services will be given equal priority, resulting in quality train paths.'

Annex 2

Scale used for the survey

GAP

5	Achieved nowhere
4	Only partially achieved in isolated areas
3	Achieved fully in isolated areas
2	Partially achieved across most of Europe
1	Achieved across most of Europe

Difficulty (Operational, Technical, Commercial)

5	Very significant scientific research and capital investment required. Deployment possible within 8–10 years or more
4	Significant scientific research required. Deployment possible within 5–7 years, significant investment required
3	Integration of existing technological, operational and business models. Deployment possible within 3–4 years, significant investment required
2	Integration of existing technological, operational or business models. Deployment possible within 1–2 years, with minimal capital investment
1	Integration of existing technological, operational and business models. Deployment possible within 1 year with minimal capital investment.

Potential - Modal Shift

5	Full achievement of 2011 White Paper targets - 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050
4	Partial achievement of White Paper targets 22% by 2030 and 38% by 2050
3	Partial achievement of White Paper targets 15% by 2030 and 25% by 2050
2	Partial achievement of White Paper targets 8% by 2030 and 13% by 2050
1	Nominal modal shift

Potential - Intermodal logistics competitiveness for distances greater than 300 km

5	The relative competitiveness of intermodal transport will significantly increase
4	The relative competitiveness of an intermodal transport will increase
3	The relative competitiveness of an intermodal transport will slightly increase
2	The relative competitiveness of an intermodal transport will slightly decrease
1	The relative competitiveness of an intermodal transport will significantly decrease
0	No impact at the competitive equilibrium distance of 300 km.

Potential - Rail System Equipment Supplier Competitiveness

5	Staying ahead worldwide by supplying benchmark & leading products to the European and global markets
4	Staying ahead and competitive thanks to product offers with technology and process advances and to making use of European Innovations
3	Staying ahead only thanks to EU-regularities, strong worldwide service networks and thanks to co-operations, including technology transfer
2	Staying neutral regarding competitiveness in all branches (European reputation has diminished and costs becoming the only determining factor)
1	Losing ground in mass markets since the market accepts technology and functional compromises

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